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U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

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REPORT
ON
LONG LAKE
STEUBEN COUNTY
INDIANA
EPA REGION V
WORKING PAPER No. 332

WITH THE COOPERATION OF THE
INDIANA STATE BOARD OF HEALTH
AND THE
INDIANA NATIONAL GUARD
MAY, 1976

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nation-wide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

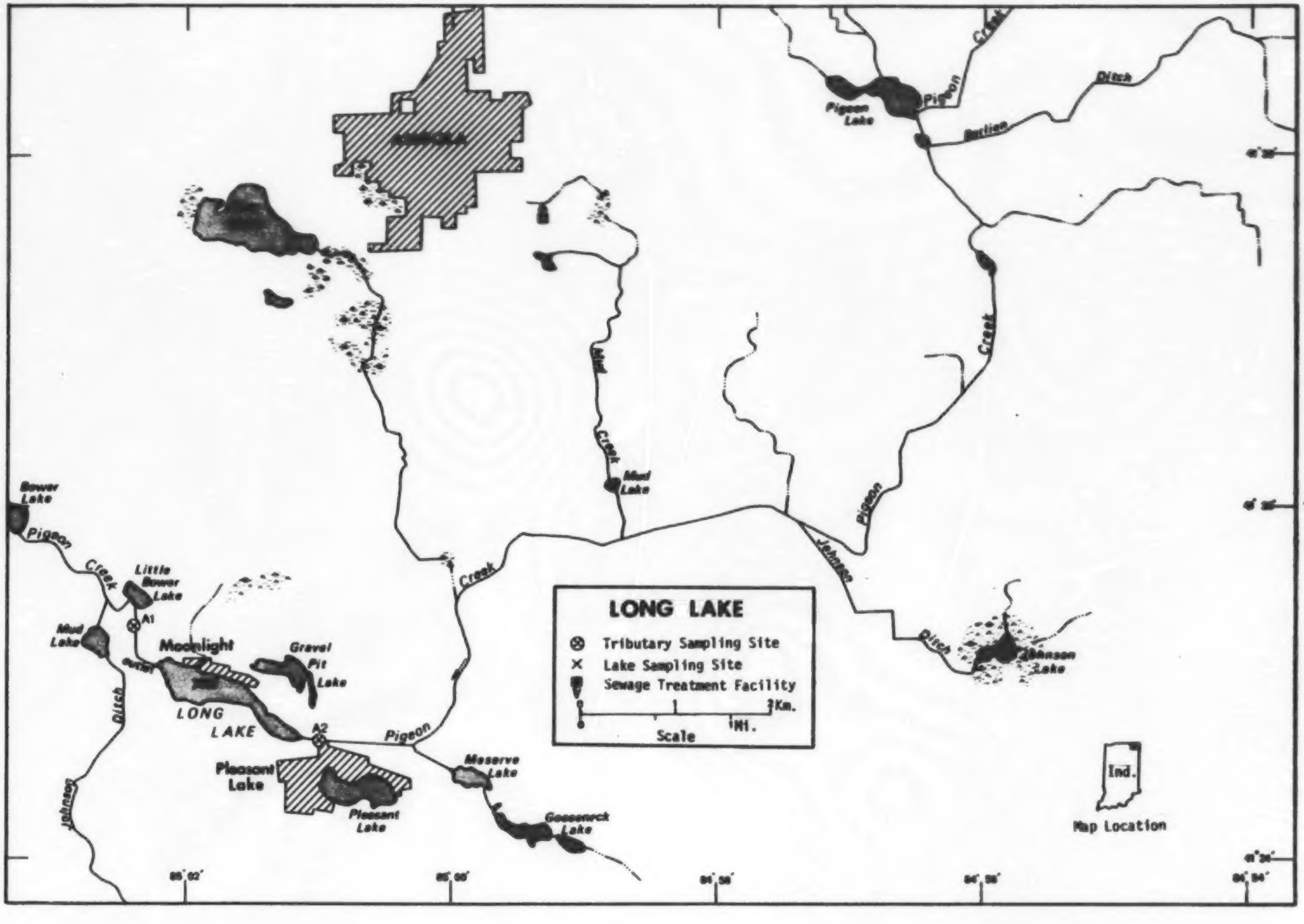
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


LONG LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Scale
1
3Km.
1Mi.
Map Location
Ind.
Pigeon Lake
Pigeon
Creek
Ditch
Mud Lake
Bower Lake
Little Bower Lake
A1
A2
Moonlight
LONG LAKE
Gravel Pit Lake
Pleasant Lake
Meserve Lake
Goosenck Lake
Johnson Lake
Johnson
Ditch

LONG LAKE

STORET NO. 1854

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Long Lake is eutrophic. Of the 27 Indiana lakes sampled in 1973, it ranked twenty-sixth in overall trophic quality when compared using a combination of six parameters*. All of the other lakes had less median total and dissolved phosphorus, 24 had less median inorganic nitrogen, 17 had less mean chlorophyll a, and 14 had greater mean Secchi disc transparency. Marked depression of dissolved oxygen occurred in the hypolimnion in August and October.

B. Rate-Limiting Nutrient:

The algal assay results indicate tnat Long Lake was limited by phosphorus at the time the sample was collected (05/02/73). However, the lake data indicate nitrogen limitation in August and October.

C. Nutrient Controllability:

1. Point sources--Point-source phosphorus contributions accounted for 23.5% of the total load reaching Long Lake during the sampling year. The Angola wastewater treatment plant contributed 23.4% of the total load.

* See Appendix A.

The present phosphorus loading of 29.54 $g/m^2/yr$ is over twelve times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 12). However, the mean hydraulic retention time of Long Lake is a short 13 days, and it is not likely that Vollenweider's model is applicable. Nonetheless, the existing trophic condition of the lake is evidence of excessive nutrient loadings.

Complete removal of phosphorus at the Angola plant would reduce the loading rate to 22.6 $g/m^2/yr$; and, regardless of the applicability of Vollenweider's model, it appears that control of phosphorus from all sources will be necessary to achieve the greatest possible improvement in the trophic condition of Long Lake (see below).

2. Non-point sources--The phosphorus contribution of non-point sources amounted to 76.5% of the total load to the lake. Pigeon Creek contributed 73.7%, and the ungaged tributaries were estimated to have contributed 2.7% of the total.

Pigeon Creek had a phosphorus export rate of 49 $kg/km^2/yr$. This is rather high as compared to the rates of tributaries of nearby Crooked*, Hamilton*, and Oliver* lakes; e.g., Unnamed Stream D-1, 21 $kg/km^2/yr$; Black Creek, 26 $kg/km^2/yr$; and Dove Creek, 11 $kg/km^2/yr$. Since all known point sources are accounted for, this export rate indicates agricultural practices and/or combined sewer overflow at Angola probably impact the creek and subsequently the lake.

* Respectively, Working Paper No. 325, 328, and 339.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 0.37 kilometers^2.
2. Mean depth: 5.1 meters.
3. Maximum depth: 9.7 meters.
4. Volume: 1.887×10^6 m^3.
5. Mean hydraulic retention time: 13 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Pigeon Creek	164.7	1.56
Minor tributaries & immediate drainage -	11.0	0.10
Totals	175.7	1.66

2. Outlet -

Pigeon Creek	176.1**	1.66

C. Precipitation***:

1. Year of sampling: 111.6 centimeters.
2. Mean annual: 91.3 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Long Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at one station on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was collected for phytoplankton identification and enumeration, and a similar sample was taken for chlorophyll a analysis. During the first visit, a single 18.9-liter depth-integrated sample was collected for algal assays. The maximum depth sampled was 9.1 meters.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LONG LAKE
STORET CODE 1854

	1ST SAMPLING (5/ 2/73)			2ND SAMPLING (8/ 6/73)			3RD SAMPLING (10/13/73)		
	1 SITES			1 SITES			1 SITES		
PARAMETER	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN	RANGE	MEAN	MEDIAN
TEMP (C)	9.3 - 13.9	12.6	13.6	11.4 - 22.8	17.1	16.5	10.5 - 17.6	14.9	15.0
DISS OXY (MG/L)	5.5 - 9.8	7.5	7.4	0.0 - 9.2	2.8	0.2	0.2 - 6.0	2.2	0.2
CNDCTVY (MCROMO)	625. - 650.	633.	625.	506. - 621.	552.	536.	569. - 635.	604.	613.
PH (STAND UNITS)	7.6 - 7.9	7.8	7.9	7.4 - 8.3	7.6	7.4	7.3 - 8.0	7.7	7.7
TOT ALK (MG/L)	200. - 218.	204.	200.	264. - 322.	280.	266.	230. - 345.	271.	250.
TOT P (MG/L)	0.095 - 0.118	0.104	0.101	0.081 - 1.170	0.388	0.218	0.204 - 0.860	0.406	0.351
ORTHO P (MG/L)	0.029 - 0.080	0.042	0.031	0.033 - 0.880	0.296	0.180	0.150 - 0.712	0.328	0.277
NO2+NO3 (MG/L)	1.600 - 2.100	1.960	2.100	0.160 - 1.400	0.948	0.990	0.050 - 0.480	0.246	0.330
AMMONIA (MG/L)	0.050 - 0.450	0.146	0.070	0.080 - 3.600	1.082	0.610	0.390 - 7.270	2.134	0.770
KJEL N (MG/L)	1.400 - 1.600	1.500	1.500	1.500 - 5.400	2.620	2.280	1.680 -10.000	3.720	2.000
INORG N (MG/L)	2.000 - 2.170	2.106	2.150	1.070 - 3.760	2.030	1.810	0.790 - 7.320	2.380	1.100
TOTAL N (MG/L)	3.100 - 3.700	3.460	3.500	2.790 - 5.560	3.568	3.190	1.990 -10.050	3.966	2.330
CHLRPYL A (UG/L)	31.8 - 31.8	31.8	31.8	11.2 - 11.2	11.2	11.2	5.3 - 5.3	5.3	5.3
SECCHI (METERS)	1.0 - 1.0	1.0	1.0	1.4 - 1.4	1.4	1.4	2.0 - 2.0	2.0	2.0

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/02/73	1. Cryptomonas sp.	1,784
	2. Dinobryon sp.	1,407
	3. Melosira sp.	854
	4. Flagellates	427
	5. Asterionella sp.	301
	Other genera	1,182
	Total	5,955
08/06/73	1. Fragilaria sp.	2,961
	2. Melosira sp.	455
	3. Blue-green filaments	253
	4. Cryptomonas sp.	76
	5. Schroederia sp.	76
	Other genera	101
	Total	3,922
10/13/73	1. Flagellates	159
	2. Cryptomonas sp.	63
	3. Mallomonas sp.	63
	4. Ceratium sp.	48
	5. Coelastrum sp.	32
	Other genera	79
	Total	444

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/02/73	1	31.8
08/06/73	1	11.2
10/13/73	1	5.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.035	2.450	7.8
0.050 P	0.085	2.450	22.8
0.050 P + 1.0 N	0.085	3.450	22.7
1.0 N	0.035	3.450	7.3

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Long Lake was high at the time the sample was collected. Also, the significant increase in yield when phosphorus alone was added indicates that the lake was limited by phosphorus at that time. Note that the addition of nitrogen alone resulted in a yield which did not differ significantly from that of the control.

The lake data substantiate phosphorus limitation at the time the sample was taken (05/02/73); i.e., the mean inorganic nitrogen/orthophosphorus ratio was 50/1. However, nitrogen limitation is indicated in August and October (the mean N/P ratio was 7/1 both times, and nitrogen limitation would be expected).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected at station A-2. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in kg/km^2/year, at stations A-2 and B-1 of nearby Pigeon Lake** and multiplying the means by the ZZ area in km^2.

The operator of the Angola wastewater treatment plant provided monthly effluent samples and corresponding flow data.

The estimated phosphorus load from septic tanks was reduced by 50%

* See Working Paper No. 175.
** Working Paper No. 340.

to adjust for the phosphate detergent ban in effect in Indiana since January, 1972.

A. Waste Sources:

1. Known municipal† -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Angola	5,117*	tr. filter**	2,700.5	Mud Creek

2. Known industrial - None

† Anonymous, 1971.
* 1970 Census.
** Phosphorus removal added in 1975 (BonHomme, 1976).

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Pigeon Creek	8,060	73.7
b. Minor tributaries & immediate drainage (non-point load) -	295	2.7
c. Known municipal STP's -		
Angola	2,560	23.4
d. Septic tanks* -	10	0.1
e. Known industrial - None	-	-
f. Direct precipitation** -	5	<0.1
Total	10,930	100.0

2. Outputs -

Lake outlet - Pigeon Creek 7,290

3. Net annual P accumulation - 3,640 kg.

* Estimate based on 74 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Pigeon Creek	195,515	88.6
b. Minor tributaries & immediate drainage (non-point load) -	15,165	6.9
c. Known municipal STP's -		
Angola	8,915	4.0
d. Septic tanks* -	790	0.3
e. Known industrial - None	-	-
f. Direct precipitation** -	400	0.2
Total	220,785	100.0

2. Outputs -

Lake outlet - Pigeon Creek 199,130

3. Net annual N accumulation - 21,655 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Pigeon Creek	49	1,187

* Estimate based on 74 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	29.54	9.84	596.7	58.5

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Long Lake:	
"Dangerous" (eutrophic loading)	2.30
"Permissible" (oligotrophic loading)	1.15

V. LITERATURE REVIEWED

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1805	CATARACT LAKE	0.058	1.660	466.667	10.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.009
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.006
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1828	MONROE RESERVOIR	0.025	0.325	438.623	6.947	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	364.500	5.000	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLER LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.900	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.400	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.067	15.000	0.014
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	469.833	47.480	14.800	0.017
1849	HOVEY LAKE	0.062	1.050	489.333	84.267	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
1852	CROOKED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.016	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.100	15.000	0.150
1855	PIGEON LAKE	0.058	1.945	442.667	11.900	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.018

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	580-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MORSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITMER LAKE	279
16	1840	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1805	CATARACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1854 LONG LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 175.9

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1854A1	176.1	2.23	2.55	3.54	3.34	2.19	1.64	1.01	0.48	0.36	0.39	0.87	1.55	1.67
1854A2	164.7	2.08	2.38	3.31	3.14	2.05	1.54	0.94	0.37	0.33	0.37	0.81	1.46	1.56
1854ZZ	10.9	0.122	0.156	0.227	0.210	0.133	0.102	0.059	0.018	0.018	0.019	0.054	0.102	0.101

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 175.9
SUM OF SUB-DRAINAGE AREAS = 175.6

TOTAL FLOW IN = 20.88
TOTAL FLOW OUT = 20.87

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1854A1	6	73	2.342	10	3.511				
	7	73	1.032	15	2.945				
	8	73	1.053	12	1.848				
	9	73	0.473	16	0.425				
	10	73	0.334	10	0.368				
	11	73	0.351	10	0.311				
	12	73	0.872	8	0.793				
	1	74	2.268	6	1.727				
	2	74	2.778	10	2.435	24	3.341		
	3	74	2.387	12	3.568	26	1.444		
	4	74	2.254	7	2.032				
	5	74	1.937	5	1.359				
1854A2	6	73	1.852	10	2.775				
	7	73	1.447	15	2.322				
	8	73	0.833	12	0.821				
	9	73	0.374	16	0.340				
	10	73	0.263	10	0.283				
	11	73	0.276	10	0.238				
	12	73	0.688	8	0.623				
	1	74	1.792	6	1.359				
	2	74	2.195	10	1.926	24	2.633		
	3	74	1.886	12	2.832	26	1.133		
	4	74	1.778	7	2.237				
	5	74	1.532	5	1.076				
1854ZZ	6	73	0.122	10	0.184				
	7	73	0.095	15	0.153				
	8	73	0.055	12	0.054				
	9	73	0.025	16	0.022				
	10	73	0.017	10	0.019				
	11	73	0.018	10	0.016				
	12	73	0.045	8	0.042				
	1	74	0.118	6	0.091				
	2	74	0.145	10	0.127	24	0.173		
	3	74	0.125	12	0.187	26	0.074		
	4	74	0.117	7	0.147				
	5	74	0.101	5	0.071				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

185401
41 34 57.0 085 01 55.0 3
LONG LAKE
18151 INDIANA

083292

11EPALES 2111202
0033 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/02	17 00	0000	13.9		40	640	7.70	210	0.070	1.600	2.100	0.031
	17 00	0006	13.8	9.8		625	7.90	200	0.050	1.400	2.100	0.030
	17 00	0015	13.6	8.8		625	7.90	200	0.060	1.600	2.100	0.029
	17 00	0022	12.2	6.0		625	7.90	200	0.100	1.400	1.900	0.039
	17 00	0029	9.3	5.5		650	7.60	200	0.450	1.500	1.600	0.080
73/08/06	12 20	0000	22.8	9.2	54	621	8.30	264	0.080	1.800	0.990	0.033
	12 20	0005	21.8	4.6		585	7.60	266	0.190	1.500	1.400	0.069
	12 20	0010	21.1			571						
	12 20	0015	16.5	0.0		531	7.40	266	0.610	2.200	1.200	0.180
	12 20	0020	13.5	0.2		506	7.40	280	0.930	2.200	0.990	0.319
	12 20	0025	12.3			515						
	12 20	0030	11.4	0.2		536	7.40	322	3.600	5.400	0.160	0.880
73/10/13	11 35	0000	17.6	6.0	78	635	8.00	244	0.390	1.800	0.400	0.150
	11 05	0008	17.4	4.4		630	7.90	230	0.440	1.600	0.390	0.173
	11 05	0015	15.8	0.2		613	7.70	250	0.770	2.000	0.330	0.277
	11 05	0020	14.0	0.2		572	7.60	285	1.800	3.200	0.060	0.712
	11 05	0025	10.5	0.2		569	7.30	345	7.270	10.000	0.050	0.330

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/02	17 00	0000	0.101	31.8
	17 00	0006	0.105	
	17 00	0015	0.095	
	17 00	0022	0.099	
	17 00	0029	0.118	
73/08/06	12 20	0000	0.041	11.2
	12 20	0005	0.108	
	12 20	0015	0.218	
	12 20	0020	0.321	
	12 20	0030	1.170	
73/10/13	11 05	0000	0.204	5.3
	11 05	0008	0.236	
	11 05	0015	0.351	
	11 05	0020	0.860	
	11 05	0025	0.381	

30A

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/03/30

1854A1
41 35 18.0 085 02 28.0 4
PIGEON CREEK
18 7.5 ASHLEY
O/LONG LAKE 083292
RD XING .5 MI NW OF MOONLIGHT
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/10	10 20		1.680	2.200	0.138	0.080	0.130
73/07/15	11 55		1.740	3.000	0.093	0.076	0.220
73/08/12	11 20		0.630	2.100	0.060	0.016	0.095
73/09/16	08 50		0.176	1.300	0.069	0.035	0.120
73/10/10	16 50		0.357	1.800	0.252	0.120	0.175
73/11/10	10 30		0.570	1.600	0.440	0.160	0.205
73/12/08	10 00		1.400	1.400	0.350	0.104	0.160
74/01/06	09 20		3.520	2.100	0.312	0.064	0.125
74/03/12	15 00		2.940	2.300	0.090	0.045	0.125
74/03/26	17 00		2.200	1.400	0.120	0.040	0.085
74/04/07	13 55		1.500	1.300	0.030	0.010	0.035
74/05/05	13 10		1.100	1.400	0.130	0.070	0.170

STORET RETRIEVAL DATE 76/03/30

1854A2
41 34 55.0 085 01 00.0 4
PIGEON CREEK
18 7.5 ASHLEY
I/LONG LAKE 083292
NY CENTRAL RR BRDG N EDGE OF PLEASANT LK
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/10	10 45		1.660	2.100	0.147	0.098	0.195
73/07/15	11 40		1.600	2.310	0.132	0.094	0.280
73/08/12	11 30		0.900	2.200	0.185	0.092	0.290
73/09/16	08 25		1.040	1.540	0.198	0.210	0.350
73/10/10	16 40		0.820	1.500	0.300	0.310	0.430
73/11/10	10 15		0.870	1.500	0.368	0.320	0.375
73/12/08	09 45		1.600	1.200	0.270	0.116	0.190
74/01/06	09 15		4.400	1.600	0.252	0.056	0.100
74/02/10	09 25		2.900	2.000	0.260	0.060	0.125
74/02/24	09 51		0.220	2.100	0.160	0.050	0.185
74/03/12	16 35		2.940	2.300	0.115	0.040	0.115
74/03/26	17 20		2.100	1.400	0.145	0.045	0.085
74/04/07	13 20		2.640	2.100	0.075	0.040	0.115
74/05/05	12 40		1.850	0.800	0.055	0.095	0.150

STORET RETRIEVAL DATE 76/03/30

1854XA TF1854XA P005117
41 37 40.0 084 59 12.0 4
ANGOLA
18 7.5 ANGOLA E
T/LONG LAKE 083291
MUD CREEK
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/06/13	07 00		2.700	3.900	0.240	1.400	2.000	0.830	0.687
73/07/13	07 30		2.700	3.100	0.300	0.720	1.550	0.845	0.734
73/08/12	08 00		0.480	9.650	0.200	0.790	3.300	0.317	0.772
73/09/13	07 45		5.450	3.200	0.378	3.100	3.635	0.617	0.715
73/10/12	07 00		3.780	7.800	0.110	3.990	5.200	0.674	0.637
73/11/13	07 00		5.200	7.500	0.060	3.500	3.900	0.641	0.633
73/12/13	08 00		1.260	3.800	0.470	0.900	1.000	0.750	0.650
74/01/14	10 00		6.300	7.500	0.290	1.680	4.400	0.750	0.671
74/02/13	08 30		4.300	5.800	0.130	1.560	2.200	0.650	0.721
74/03/13	14 00		3.200	3.500	0.180	0.670	1.100	0.650	0.820
74/04/12	10 00		2.880	1.200	0.100	1.150	1.350	1.030	0.777
74/05/13	14 30		3.900	12.000	0.180	1.800	3.150	0.774	0.763
74/06/13	08 00		5.900	4.100	0.250	1.710	2.400		0.694